Energy and Resources Group (ERG) & Goldman School of Public Policy

Energy and Society
ER 100 / 200 and Pub Pol C184 / C284

Professor **Daniel M Kammen**
Email: kammen@berkeley.edu | Twitter: @dan_kammen
Office Hours: Wednesdays mornings in 326 Barrows Hall - https://www.wejoinin.com/sheets/hoxnz.

Section	Day/time	Rm. No.	ER100 CC#	ER200 CC#	PP184 CC#	PP284 CC#
101	W 11 - 12	107 Genetics & Plant Biology	23289	23312	40374	40320
102	F 12 - 1	229 Dwinelle	23290	23313	40375	40321
103	W 1 - 2	209 Dwinelle	23291	23314	40376	40313
104	Th 12 - 1	200 Wheeler	23292	23315	40377	40314
105	M 12 – 1	108 Wheeler	23293	23316	40378	40315
106	M 1 – 2 Th 2-3	209 Dwinelle 381 Barrows Shasta Conf Rm	23294	23317	40379	40316

Note: sections begin the week of August 28

Course websites:	bCourses	(course internal)
	http://nature.berkeley.edu/er100	(open access site)

Among the questions we will address in this course are:

- ***In what ways has fossil-fuel use defined the 20th Century? What about the 21st?***
- ***What role is there for renewable energy and energy efficiency today and in the future?***
- ***What is the role of nuclear power in our present and future energy mix?***
- ***Could fuel cells or the hydrogen economy cause a revolution in the automotive industry?***
- ***Is the U. S. ready to acknowledge and address global warming?***
- ***How are energy issues different in developing nations from those in the 'North'?***
- ***What tools do you need to address these questions from an interdisciplinary perspective?***

Interested in these questions? Then Energy and Society is for you.

Each of these questions about the use and impacts of energy systems requires an interdisciplinary understanding that explores the scientific, technical, economic, social, political, and environmental opportunities and impacts of our energy system.

In this course, you will develop an understanding—and a technically and socially deep working knowledge—of our energy technologies, policies, and options. This will include analysis of the different opportunities and impacts of energy systems that exist within and between groups defined by national, regional, household, ethnic, and gender distinctions. Analysis of the range of current and future energy choices will be stressed, as well as the role of energy in determining local environmental conditions and the global climate.

ER200/GSPP284 are graduate versions of ER100/GSPP184, and their lectures and sections are held in common. ER200/GSPP284 includes additional material, with added analytic tools and problems on both the problem sets and the examinations. *Grading for the undergraduate and graduate courses are separate*.

Course Goals

This course is designed to provide you with the methods, tools and perspectives to understand, critique, and ultimately influence the management of technical, economic, and policy choices regarding the options for energy generation and use. We will focus equally on the technical, socioeconomic, political, and environmental impacts of energy.

We will examine the full 'life cycle', or 'cradle to grave to cradle again' of energy, from the stage of raw materials, or inputs, to generation, conversion, distribution, consumption, recycling, waste, impacts, and ethnic, racial, gender, and economic inequities. This work is inherently interdisciplinary, and will involve a fascinating but extensive effort to understand, critique, and integrate tools and perspectives from anthropology, cultural and ethnic studies, economics, engineering, physics, politics, sociology, and who knows what else.

The challenge of this integration is not simply one of learning and applying methods from very diverse disciplines, but more importantly is one of understanding how and when different types of analysis, disciplinary and political perspectives, and "voices" are heard, unheard, ignored, or discredited. Energy is a fundamental societal resource, the control of which reflects and shapes interactions both within society and between humans and the natural environment.

Coverage

Over the semester we will take a roughly chronological tour of the major fuel types used in human civilization. From there we will begin a broad-ranging analysis of the energy resource, combustion or conversion processes, application, waste, economic, social, political, cultural, and environmental impacts and options associated with these fuels and with the changing mix of fuels used within and across societies around the globe.

Assignments
There will be seven problem sets and a policy memo (in total 40% of the grade), a mid-term examination (25%), and a final exam (35%).

Problem sets are distributed every other Tuesday, and due back, in class, the Thursday of the following week. You may also turn the assignment in at the box located in the hallway outside the ERG office (310 Barrows) **BEFORE 6pm Thursday**. Late assignments will be penalized 30% if turned in by 5pm on Monday, when the solution set will be posted.

You will get the most out of the problem sets if you make an initial effort to work through all of the problems on your own. After attempting to solve the problems on your own, you may then work with other students to discuss different approaches. It is vital that you do your own work. It is a violation of the Code of Student Conduct to copy answers from anyone.

As part of your participation in the course, you are encouraged to use the bCourses discussion board to make comments and/or ask questions related to the readings or lectures. We will also post the answers to questions about the problem sets on bCourses, so be sure to check bCourses regularly.

Web-based readings: A number of readings, both *required and supplemental*, are available on-line. In order to download some of these, you will need to use an on-campus computer or set up your home computer or laptop with the campus proxy service. For instructions, see:
http://www.lib.berkeley.edu/using-the-libraries/connect-off-campus

All readings are also available on the course bCourses site and on nature.berkeley.edu

Required Reading* assignments should be completed before the lecture for which they are assigned. While I recognize that this is not always possible, you need to try; the material in lecture *does not simply review the readings*; *we use it as a basis for exploration of the course material and ideas.

Optional Field Trips

There will be several field trips during the semester. Each will be 3 - 6 hours (including travel time), and all will be Friday mornings. The list will depend on availability, but will likely include:

- The Pittsburgh Energy 'Park', a 2200 MW fossil-fuel power plant (gas and oil);
- California Windfarm
- FlexLab, LBL
- SunSet Solar (San Francisco)

Graduate Student Instructors and Office Hours

	Grace Horvath	**Kelly Jiang**	**Christian G Miller**	**Sara Mulhauser**
Office:	399 Barrows	399 Barrows	399 Barrows	321 Barrows
Hours:	Fri 2-10 AM	Tues 9–11 AM	T 2-3, W 12-1	Wed 2–4 PM
Email:	gracehorvath [at] berkeley.edu	keljia [at] berkeley.edu	cgmiller [at] berkeley.edu	sara.mulhauser [at] berkeley.edu

Reach us by email or by coming to the office hours.

Section meetings begin in Week 2 (i.e. starting 8/29).

Lecture Slides

Lecture slides (.pdf files) will be available for each lecture, and will be posted on the course website before the lecture. You should download the files and bring them to lecture so that you have all of the graphs and diagrams right in front of you.

Wk	Date	Lecturer	Lecture #/Topic
1	8-24	Kammen	1. How Energy Use Shapes Society & the Environment
2	8-29	Kammen	2. Energy Toolkit I: Units, Forecasts, and the Back-of-the-Envelope
	8-31	Kammen	3. Energy Toolkit II: Fuels, Energy Content & Basics of Combustion
3	9-5	Kammen	4. Energy for 'the South' I: Energy Transitions and Development
	9-7	Kammen	5. Energy for 'the South' II: Biomass, Households, and Gender
4	9-12	Guest	6. Energy Toolkit III: Energy Thermodynamics
	9-14	Kammen	~~7. Energy Toolkit IV: Thermodynamics of Modern Power Plants~~ cancelled
5	9-19	Kammen	8. Energy Toolkit IV: Thermodynamics of Modern Power Plants, and 'Hydrocarbon Man'
	9-21	Kammen	9. 'Hydrocarbon Man' cont., and Evolution of the Modern Energy Economy
6	9-26	Kammen	10. Energy Toolkit V: Economic Analysis of Energy Systems
	9-28	Horvath	11. Energy Toolkit VI: Life-Cycle and Cost-Benefit Analysis
7	10-3	Kammen	12. Energy Efficiency I: Devices
	10-5	Kammen	13. Energy Efficiency II: Buildings and Larger Energy Systems
8	10-10	Callaway	14. Electricity Grids: Managing the Network
	10-12	Kammen	15. Natural Gas, Fracking, and Carbon Capture and Storage
9	10-17	GSIs	Mid-term review
	10-19	**You!**	**Midterm Exam, In class**
10	10-24	Guest	16. Nuclear Energy I: Physics and Engineering – Fission & Fusion
	10-26	Kammen	17. Nuclear Energy II: Waste, Risk & Economics
11	10-31	Guest	18. Energy Toolkit VII - Energy and Environmental Justice I (theory)
	11-2	Guest	19. Energy Toolkit VII - Energy and Environmental Justice II (practice)
12	11-7	Kammen	20. Renewable Energy I: Solar Energy
	11-9	Kammen	21. Renewable Energy II: Wind, Geothermal & Hydropower
13	11-14	Kammen	22. Renewable Energy III: Electrochemistry - H_2, Fuel Cells & storage
	11-16	Kammen	23. Renewable Energy IV: Industrial Bioenergy & Land Use
14	11-21	Kammen	24. Transportation systems and policies
	11-23		**HOLIDAY THANKSGIVING**
15	11-28	Kammen	25. Climate Change I: Energy and Climate
	11-30	Kammen	26. Climate Change II: Energy Policy

Final Exam: Group 20: Friday, December 15, 7 – 10 pm

Problem Set #	Assigned	Due	Coverage
1	**8/29**	**9/7**	Short warm-up problems; analysis of utility bills; making unit analysis your friend, and getting comfortable with the myriad of energy units. These problems may be unfamiliar in style for many of you; if necessary use the GSI's and study groups to 'get into the swing' of these calculations/estimates. You must, however, do your own work.
2	**9/12**	**9/21**	Energy use at household and national scales; basic thermodynamics; combustion.
3	**9/26**	**10/5**	Thermodynamics of energy systems, combustion of various fuels; comparisons of energy conversion efficiencies, emissions, financial analysis of power plants. Energy economics.
4	**10/5***	**10/12**	Life-cycle analysis; learning curves; energy efficiency, evolution of the modern energy system. [Shorter problem set]
5	**10/24**	**11/2**	Environmental justice; energy efficiency and conservation; the grid; nuclear energy.
6	**11/7**	**11/16**	Nuclear energy and waste, renewable energy systems, fuel cells and hydrogen.
7	**11/21**	**11/30**	Biomass energy, transportation, energy and climate, and climate policy.

*** Note: non-standard assignment dates (mid-term & thanksgiving). No late assignments accepted for PS #4 so that we can return to you graded problem sets on 10/17, prior to the exam.**

Problem sets are posted on the web, not physically distributed in class**.**

Do not leave problem sets for the final few days. They are not hard if started early; they can be an unpleasant experience if left for the night before they are due.

Problem sets are due in class or can be turned in to the problem set drop-off box outside of the Energy and Resources Group, 310 Barrows Hall. Problem sets are late after 6:00 PM.

Problem sets cannot be turned in electronically or by fax.

You should be familiar with the readings listed for each lecture date when the lecture occurs—they will be referenced under the assumption that you have read them already. Readings listed for **ER200/PP284** *are required for graduate students. Readings listed as* **Supplemental** *will (perhaps obviously) supplement your understanding of the course material, but are not required to successfully complete the course.*

Week 1 – Introduction to Energy Systems and Society

Lecture 1 (8/24) – Energy and Society: How Energy Use Shapes Society & the Environment:

Recommendation: Get in the habit of looking for energy articles in newspapers and begin to get a feel for how ubiquitous and far-reaching energy issues are in society. In addition, check the opinion ("OpEd") and editorial pages of your favorite newspapers. As your last assignment of the course, you will be writing a 'policy memo' that in most cases can and should be submitted as an Op Ed yourself

Yergin, D. (1991) The Prize: The Epic Quest for Oil, Money, and Power (Simon & Schuster: New York).
Pages 11 – 16.[Yergin_1991.pdf]

Plus, read a selection – you decide how many -- of these energy-related op-eds or others you look up (a good habit).

Read these 'classic' energy op eds:

Jeffrey Ball and Dan Reicher (2017) "Making solar big enough to matter" (3/21/2017)
https://www.nytimes.com/2017/03/21/opinion/making-solar-big-enough-to-matter.html?mcubz=1

Ralph Cavanagh (2013) "How we learned not to guzzle" (9/12/13)
http://www.nytimes.com/2013/09/13/opinion/how-we-learned-not-to-guzzle.html?_r=0

Kendyl Crawford (2016) "Addressing Environmental Justice in the Commonwealth"(3/23/2016)
http://altdaily.com/op-ed-addressing-environmental-justice-in-the-commonwealth/

Ban Ki-Moon (2012) "Powering sustainable energy for all" (1/11/12)
http://www.nytimes.com/2012/01/12/opinion/powering-sustainable-energy-for-all.html

Paul Krugman (2017) "Trump's energy, low and dirty" (5/29/2017)
https://www.nytimes.com/2017/05/29/opinion/trump-g-7-summit-energy.html?mcubz=1

There are many outlets to follow. For some local ones, see : @dan_kammen which is from the Renewable and Appropriate Energy Laboratory, rael.berkeley.edu, and "Energy @ Haas"

Week 2 – Methods in Energy Analysis

Lecture 2 (8/29) – Energy Toolkit I: Units, Forecasts, and the Back-of-the-Envelope:

Lovins, Amory (1976) "Energy Strategy: The Road Not Taken", *Foreign Affairs*, **55(1):** 65–96. [Lovins_1976.pdf]

Commentary on the Lovins paper from *The New York Times:*
John Tierney (2008) "A gift from the '70s: Energy lessons" (10/6/2008)
http://www.nytimes.com/2008/10/07/science/07tier.html?_r=1&8dpc&oref=slogin

ER200 & PP284:
Rubin, Edward S. (2001) *Introduction to Engineering & the Environment* (McGraw Hill: New York, NY) [**Rubin**, *EE*], *Rates of Technology Adoption*, Pages 669 – 677.

Supplemental:
Toolkit 1 (a review and refresher) – optional/reference for those who have done these sorts of problems before.

Lecture 3 (8/31) – Energy Toolkit II: Fuels, Energy Content, and Basics of Combustion:

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 39–47. [Masters_1991_Enviro_Chemistry.pdf]

Supplemental: Toolkit 2 (resource material)

Week 3 – Energy and Development

Lecture 4 (9/5) – Energy for 'the South' I: Energy Transitions and Development:

Goldemberg, J. (1996) *Energy, Environment, and Development* (Earthscan: London, UK), 11 – 37. [Goldemberg_1996.pdf]

Jacobson, A. and D.M. Kammen. (2005). "Science and Engineering Research that Values the Planet," *The Bridge*, **35**(4): pp. 11-17. [Jacobson_2005.pdf]

ER200 & PP284:

Alstone, P., Gershenson, D. and Kammen, D. M. (2015) "Decentralized energy systems for clean electricity access," *Nature Climate Change*, **5**, 305 – 314.

Lecture 5 (9/7) – Energy for 'the South' II: Biomass, Households, and Gender:

Kammen, D. M. and Dove, M. R. (1997) "The virtues of mundane science", *Environment*, **39**(6): 10–15, 38–41. [Kammen_1997.pdf]

Sovacool, B (2014) "Energy studies need social science," *Nature*, **511**, 529 – 530.

Kammen, D. M. (1995) "Cookstoves for the developing world," *Scientific American*, **273**, 72 - 75. [Kammen_1995.pdf]

ER200 & PP284:

Crewe, E. (1997) "The silent traditions of developing cooks", *Discourses of Development*, R. D. Grillo and R. L. Stirrat, eds. (Berg: Oxford, UK), 59–81. [Crewe_1997.pdf]

Bose, S. (1993) "Women, Work, and Household Electrification in Rural India," *Money, Energy and Welfare* (Oxford University Press: Bombay, India), Chapter V, pages 143 – 181. [Bose_1993.pdf]. Note: this is a challenging reading.

Supplemental: Bailis, Ezzati, Kammen, (2005) "Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa," *Science*, 308 (5718): p. 98-103. [Bailis_2005.pdf]

Week 4 – Thermodynamics of Energy

Lecture 6 (9/12) – Energy Toolkit III: Energy Thermodynamics:

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 15 – 29. [Masters_1991_Energy.pdf]

Lecture 7 (9/14) – Energy Toolkit IV: Thermodynamics of Modern Power Plants:

Rubin, Edward S. (2001) *Introduction to Engineering & the Environment* (McGraw Hill: New York, NY) [**Rubin**, *EE*], Sections 5.1 - 5.6.3 (except 5.2.2 & 5.2.3); Pages 162 – 175, 179 – 215

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 327– 339. [Masters_1991_Air_Pollution.pdf]

ER200 & PP284:
David Roberts (2017) "By 2020, every Chinese coal plant will be more efficient than every US coal plant" (5/16/2017) https://www.vox.com/energy-and-environment/2017/5/15/15634538/china-coal-cleaner

Supplemental: Beér, J. M. (2000) "Combustion technology developments in power generation in response to environmental challenges," *Progress in Energy and Combustion Science*, **26**, 301 – 327. [Beer_2000.pdf]

[This is an advanced treatment of state-of-the-art fossil-fuel power plant design issues and opportunities].

Week 5 – 'Hydrocarbon man'

Lecture 8 (9/19) – Hydrocarbon Man:

Friedman, Thomas L. (2006) "The First Law of Petropolitics," *Foreign Policy*, **154:** (28 – 36). [Friedman_2006.pdf]

Farrell, Alex E., and Brandt, Adam R. (2006) "Risks of the oil transition," *Environmental Research Letters,* **1**, October 30. [Farrell_2006_Risks.pdf]

Hirsh, Richard (1999) *Power Loss* (MIT University Press: Cambridge, MA) Section I, Pages 1 - 54.

Lecture 9 (9/21) – Evolution of the Modern Energy Economy:

Hirsh, Richard (1999) *Power Loss* (MIT University Press: Cambridge, MA) Section I, Pages 55 - 88.

Week 6 – Energy Economics and Life-Cycle Methods

Lecture 10 (9/26) – Energy Toolkit V: Economic Analysis of Energy Systems:

Rubin, *EE*, Chapter 13, Pages 545 – 577

Edenhofer, O. (2015) "King coal and the queen of subsidies," *Science*, 1286 – 1287. http://science.sciencemag.org/content/sci/349/6254/1286.full.pdf

ER200 & PP284:

Arrow, K. *et al.*, (2013) "Determining the benefits and costs for future generations," *Science*, **341**, 349 – 350.[Arrow_2013.pdf]

Lecture 11 (9/28) – Energy Toolkit VI: Life-cycle and Cost-Benefit Analysis:

Rubin, *EE*, Section 13.4, Life-cycle cost, 556 – 562.

ER200 & PP284 [Supplemental for ER100/PP184]:

Wynes, S. and Nicholas, KA (2017) "The climate mitigation gap: education and government recommendations miss the most effective individual actions" *Environmental Research Letters,* **12**, 074024. http://iopscience.iop.org/article/10.1088/1748-9326/aa7541/pdf

Hertwich, E. and Peters, G. (2009) "The carbon footprint of nations, a global, trade linked analysis", ES&T, *b,* 6414–6420. http://pubs.acs.org/doi/pdfplus/10.1021/es803496a

Supplemental:

Jones, C. M. and Kammen, D. M. (2014) "Spatial distribution of U.S. carbon footprints reveals suburbanization offsets benefits of population density", *Environmental Science and Technology*, ***48*** **(2)**, 895 – 902. https://nature.berkeley.edu/er100/readings/Jones-Kammen-2014.pdf

Week 7 – Energy Efficiency (I & II)

Lecture 12 (10/3) – Energy Efficiency I: Devices:

Rubin, *EE*, Chapter 7, and Section 13.8 of Chapter 13, Pages 281 – 314, 577 – 583.

Hirsh, Richard (1999) *Power Loss* (MIT University Press: Cambridge, MA), pages 90 – 117.

ER200 & PP284:

Attari, S. Z. DeKay, M. L. Davidson, C. I. and Bruine de Bruin, W. (2010) "Public perceptions of energy consumption and savings", *PNAS*, 2010. [Attari_2010.pdf]

Lecture 13 (10/5) – Energy Efficiency II: Buildings as Energy Systems

David B. Goldstein (2008) Extreme Efficiency: How Far Can We Go If We Really Need To? ACEEE Summer Study Paper.[Goldstein_2008.pdf]

ER200 & PP284:

Gillingham, K, *et al.,* (2013) "The rebound effect is overplayed", *Nature,* **493**, 475–476
http://www.nature.com/nature/journal/v493/n7433/full/493475a.html?foxtrotcallback=true

Supplemental:

Nagourney, A., *et al. (2015)* "California drought tests history of endless growth," *The New York Times*
http://www.nytimes.com/2015/04/05/us/california-drought-tests-history-of-endless-growth.html?smid=tw-share&_r=0

Week 8 – The Power Grid & Unconventional Fossil Fuels

Lecture 14 (10/10) – Electricity Grids: Managing the Network:

Masters, G. (2004) "Transmission and Distribution," in *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 145 – 151. [Masters_2004_TD.pdf]

von Meier, Alexandra (2006), "Reliability" and "Security," in *Electric Power Systems: a conceptual introduction* (John Wiley & Sons: New Jersey), pp. 229–234.[von_Meier_2006.pdf]

ER200 & PP284: Fairley, P. (2004) "The unruly power grid", *IEEE Spectrum*, 13 August, 5 pages. [Fairley_2004.pdf]

Reference: Glossary of electricity terms. [Electricity_Glossary.pdf]

Lecture 15 (10/12) – Natural Gas, Fracking, and Carbon Capture and Storage

Brandt, A. *et.al.*, (2014) "Methane Leaks from North American Natural Gas Systems," *Science,* **343** (6172), 733-735.

Deborah Sontag And Robert Gebeloff (2014) "The downside of the boom," *The New York Times*, 22 November, http://www.nytimes.com/interactive/2014/11/23/us/north-dakota-oil-boom-downside.html

Aisch, Gregor (2014) "What North Dakota Would Look Like if Its Oil Drilling Lines Were Above ground," *The New York Times*, November 25 https://www.nytimes.com/interactive/2014/11/24/upshot/nd-oil-well-illustration.html

ER200 & PP284:
MIT CCS roadmap - http://web.mit.edu/coal/
Chapters 2 and 3 (pages 5 – 42)

Week 9 – Mid-Term Review & Exam

Class (10/17) – Midterm examination review

Your notes, lecture slides, section handouts, past problem sets and solutions, all previous readings.

Class (10/19) – Midterm examination

Week 10 –Nuclear Power

Lecture 16 (10/24) – Nuclear Energy I: Physics and Engineering – Fission/Fusion:

Deutch and Lester, (2004) Making Technology Work, Ch. 7: Nuclear Power and Its Fuel Cycle, Cambridge Univ. Press, Cambridge, UK, p. 109-133. [Deutch_2004.pdf]

Nain, V. (2017) "Progress in nuclear power technology", *Encyclopedia of Sustainable Technologies*, Elsevier, **3.** http://dx.doi.org/10.1016/B978-0-12-409548-9.10103-4

Supplemental: Excellent online material on reactor types and performance is available at http://www.nrc.gov/reactors/power.html
In particular, review 'About the NRC', 'Nuclear security', and read about the events (power production and management) at one of the featured reactors, such as Diablo Canyon (under nuclear reactors) that provides power to northern California)

Lecture 17 (10/26) – Nuclear Energy II: Waste, Risk & Economics:

Rubin, *EE*, pages 63-68, 175-178.

Lester, Richard K. "A Roadmap for U.S. Nuclear Energy Innovation," *Issues in Science and Technology* 32, no. 2 (Winter 2016). http://issues.org/32-2/a-roadmap-for-u-s-nuclear-energy-innovation/

The Nuclear Fuel Cycle Cost Calculator:
http://thebulletin.org/nuclear-fuel-cycle-cost-calculator

ER200 & PP284:
Martin, R. (2016) "Fail-safe nuclear power," *MIT Technology Review*
https://www.technologyreview.com/s/602051/fail-safe-nuclear-power/

Supplemental:
Hultman, N., Koomey, J. G, and Kammen, D. M. (2007) "What history can tell us about the costs of future nuclear power", *Environmental Science & Technology,* **41(7):** 2088 - 2093. [Hultman_2007.pdf]

Week 11 – Energy and Environmental Justice: Theory and Practice

Lecture 18 (10/31) – Energy and Environmental Justice:

Pastor, Manuel, (2007) "Environmental Justice: Reflections from the United States", Ch. 14 in *Reclaiming Nature,* pp. 351–376.[Pastor_2007.pdf]

"Climate Change, Consumerism and the Pope with Prof. Daniel Kammen and Governor Jennifer Granholm -- In the Living Room with Henry E. Brady -- UC Public Policy Channel"
http://www.uctv.tv/shows/29853

Islamic Call on Climate Change
Wilson Dizard (2015) "Islamic scholars call on faithful to help fight climate change," *Al Jazeera America* (8/18/2015) http://america.aljazeera.com/articles/2015/8/18/islamic-scholars-issue-climate-change-declaration.html

ER200 & PP284:
Stephen J. Flusberg, Teenie Matlock & Paul H. Thibodeau (2017), "Metaphors for the War (or Race) against Climate Change", *Environmental Communication*
http://dx.doi.org/10.1080/17524032.2017.1289111

Lecture 19 (11/2) – Environmental Justice: Practice

Sunter, D., Castellanso, S., and Kammen, DM (2017) "The environmental injustice of solar energy strategies", in draft.

Week 12 – Renewable Energy I & II: Solar, Wind and Water Power, Geothermal

Lecture 20 (11/7): Solar Energy

Haegel, N, *et al.* (2017) "Terawatt-scale photovoltaics: Trajectories and challenges", *Science*, **356**, Issue 6334, pp. 141-143. DOI: 10.1126/science.aal1288

Masters, G. (2004) "Photovoltaic Materials and Electrical Characteristics." *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 445 – 463.[Masters_2004_PV.pdf]

ER200 & PP284:

SunShot Vision Study: Read the Executive Summary; Chapter 4, Photovoltaics: Technology, Cost, and Performance; and ; chapter[Solar_Vision_Study_2010.pdf]
Online Version: http://energy.gov/eere/sunshot/sunshot-vision-study

Supplementary:

Zheng, Cheng and Kammen, Daniel (2014) "An Innovation-Focused Roadmap for a Sustainable Global Photovoltaic Industry," *Energy Policy,* **67**, 159–169.
http://www.sciencedirect.com/science/article/pii/S0301421513012500

Lecture 21 (11/9) – Renewable Energy II: Wind, Hydropower and Geothermal Energy

Masters, G. (2004) "Wind Power Systems." *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 307 – 354 (pages 335-347 are supplemental), 371 – 378. [Masters_2004_Wind.pdf]

"The Chinese are obsessed with building large dams" (2015) *The British Broadcasting Corporation*
http://www.bbc.com/future/story/20151014-the-chinese-are-obsessed-with-building-giant-dams

Latrubesse, *et al.* (2017) "Damming the rivers of the Amazon basin", *Nature*, **546**, 363 – 369. doi:10.1038/nature22333

Week 13 – Renewable Energy III & IV: Electrochemistry, Fuel Cells & Storage, Bioenergy

Lecture 22 (11/14) – Renewable Energy III: Electrochemistry - H_2, Fuel Cells & storage

Masters, G. (2004) "Fuel Cells," in *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 206-228. [Masters_2004_Fuel_Cells.pdf]

Kittner, N., Lill, F. and Kammen, D. M. (2017) "Energy storage deployment and innovation: a multi-technology model for the clean energy transition" *Nature Energy*, **2**, DOI: 10.1038/nenergy.2017.125. https://rael.berkeley.edu/wp-content/uploads/2017/07/Kittner-Lill-Kammen-NatureEnergy-Storage-Innovation-2017.pdf

Lecture 23 (11/16) – Renewable Energy IV: Industrial Bioenergy and Land Use

Review the USDA - *Billion Ton Vision: https://nature.berkeley.edu/er100/readings/billion_ton_vision.pdf*

Rubin, *EE*, Chapter 3, Pages 83-123.

Cornwall, Warren (2017) "Is wood a green source of energy? Scientists are divided", *Science*, http://www.sciencemag.org/news/2017/01/wood-green-source-energy-scientists-are-divided

ER200 & PP284:

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Week 14 – Transportation Systems

Lecture 24 (11/21) – Transportation systems and policy:

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Week 15 – Energy and the Global Environment

Lecture 25 (11/28) – Climate Change I: Energy and Climate:

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